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Safe Air Traffic Control: Developing an AI System for Improved Wake Vortex Detection and Interpretation

Wake Vortex: The Problem

Aircraft generate air turbulence, known as a Wake Vortex, during flight. These vortices pose a significant threat to the safe landing of following aircraft.

Figure: Visualization of a wake vortex.

Motivation: The Need for Assistance

Currently, air traffic controllers depend heavily on their judgments to ensure safe landings. An AI assistant could augment their capabilities, enhancing both safety and efficiency.

Figure: Overseeing landings.

The Technology: LiDAR Scanning

LiDAR, a laser scanning technology, is instrumental in creating accurate 3D representations of environments or objects. Our project harnesses this technology for detecting wake vortices.

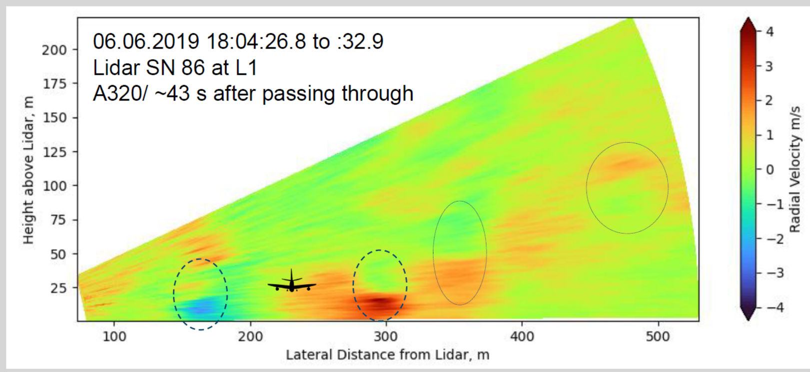


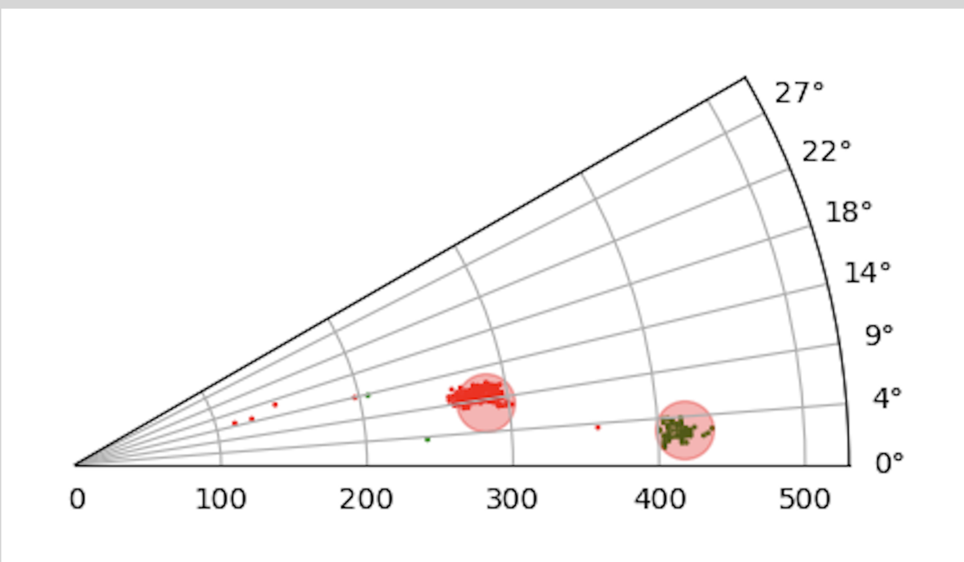
Figure: A LiDAR scan depicting a radial velocity field.

Our Goal

Our goal is to develop a fully automated, operational wake vortex detection system. Leveraging LiDAR technology, deep neural networks, and explainable AI techniques, our system aims to meet the needs of various stakeholders, including air traffic controllers and airport operators.

3D Point Cloud Analysis

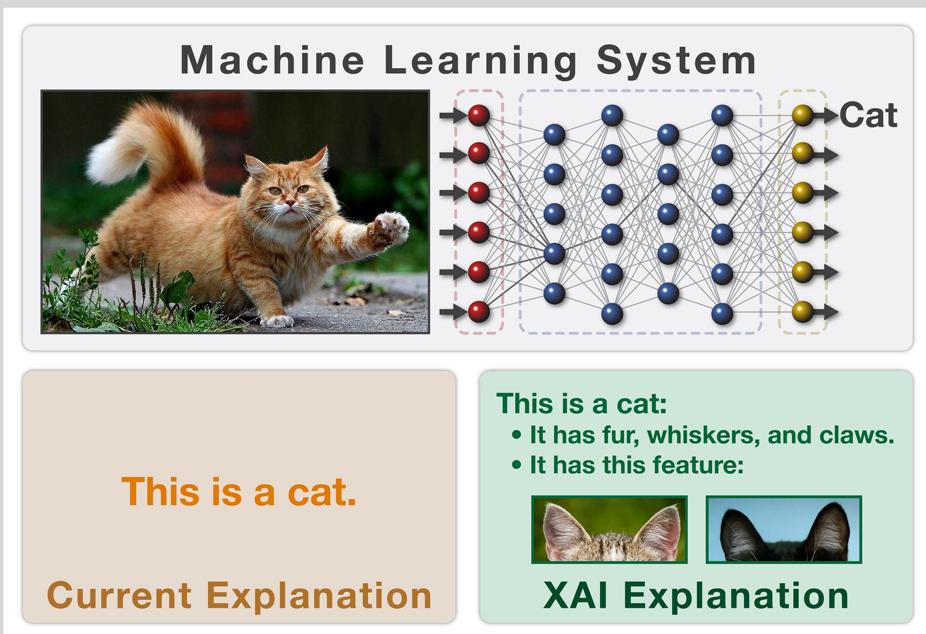
We adapt graph-based 3D Point Cloud analysis models, such as Dynamic Graph Convolution Neural Network (DGCNN, see Wang et al. (2019)).



Here, two vortices are correctly identified (the highlighted part). The circles are the cores of the Vortices.

Explainable AI (XAI)

Limited progress has been made in enhancing the explainability of 3D Point Cloud Analysis (see Tan & Kotthaus (2022)). To promote transparency and interpretability in our novel AI systems, a pioneering explanation method will be developed, leveraging cutting-edge techniques from the field of explainable AI (XAI).



In collaboration with DLR (German Aerospace Center), we address the following challenges and open questions:

- What is the best way to present the explanation? The traditional way is not applicable (e.g., the picture on the left).
- How to evaluate the explanations? No ground truth is available.
- How to incorporate domain knowledge with the explanations? If the users are experts in the field, then they will want the explanations to be aligned with their domain knowledge.

References

Wang et al. (2019): Dynamic Graph CNN for Learning on Point Clouds, ACM Transactions on Graphics (TOG), https://liuziwei7.github.io/projects/DGCNN.

Tan & Kotthaus (2022): Surrogate Model-Based Explainability Methods for Point Cloud NNs, WACV'22, https://openaccess.thecvf.com/content/WACV2022/html/Tan_Surrogate_Model-Based_Explainability_Methods_for_Point_Cloud_NNs_WACV_2022_paper.html